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Rediscovery of *Clarina syriaca* (Lederer, 1855) (Lepidoptera, Sphingidae, Macroglossinae) in Cyprus after 70 years; with notes on its biology and early life history from the Levant

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Abstract. *Clarina syriaca* (Lederer, 1855) was known from Cyprus by a single adult specimen collected in 1950. Recently, an adult and larva have been found, proving the existence of a breeding population. *Clarina syriaca* is thus confirmed as resident in Cyprus, as a relict population inhabiting riparian gallery forests, which act as isolated refugia surrounded by drier pine woodland or cultivated land. Information is provided on the early life history stages of *C. syriaca*, with further notes on its taxonomic status, biology, ecology, and host plants.

Introduction

Clarina syriaca (Lederer, 1855) (Lepidoptera: Sphingidae: Macroglossinae) is distributed from northern Turkey, southwards across eastern Turkey, down to northern and western Syria, Lebanon, Israel, and northern Jordan (Fig. 1) (Eisenstein 1984; Pittaway 1993; Müller et al. 2005a, 2005b). In southern Turkey, this local species appears to have spread farther west in recent years and can now be found as far as Antalya (Pittaway 2021). Farther east, it is replaced by its closely related sister species, *Clarina kotschyi* (Kollar, 1849) (Pittaway 1982), which occurs in southeastern Turkey (Danner et al. 1998a, 1998b; Seven 2020), Mesopotamia (Wiltshire 1957) and across the Iranian plateau (Fig. 1) (Brandt 1938; Barou 1967; Ebert 1976; Ghasemi et al. 2009). Both *C. syriaca* and *C. kotschyi* utilise *Vitis vinifera* L. as their host plant, the only (relict) western Palaearctic member of the Vitaceae family native to this region.

In Cyprus, *C. syriaca* was known only from a single adult specimen that was collected at Platres (Troodos) (Sparrow and John 2016), at an elevation of 1067 m on 19 June 1950, which is deposited in the Lepidoptera collection of the Natural History Museum, London (NHMUK) (Ian Kitching, pers. comm. 2021). Here, we report the discovery of a second adult specimen, as well as the first record of a larva.

The second adult specimen was found dead in a wine-trap within riparian (riverine) vegetation by two of the authors (MA and AA), in a deep valley (550 m) close to the village of Tsakistra, approximately 25 km NW of Platres. This locality is within the Natura 2000 Special Area of Conservation (SAC) CY2000016 and Special Protection Area (SPA) CY2000006 of Dasos Pafou (Paphos Forest). The riparian gallery forest of this area is dominated by *Platanus orientalis* L. (Platanaceae) and *Alnus orientalis* Decne (Betulaceae), which belongs to habitat type 92C0 of Annex I of the EU habitats directive 92/43/EEC (Council Directive 92/43/EEC).

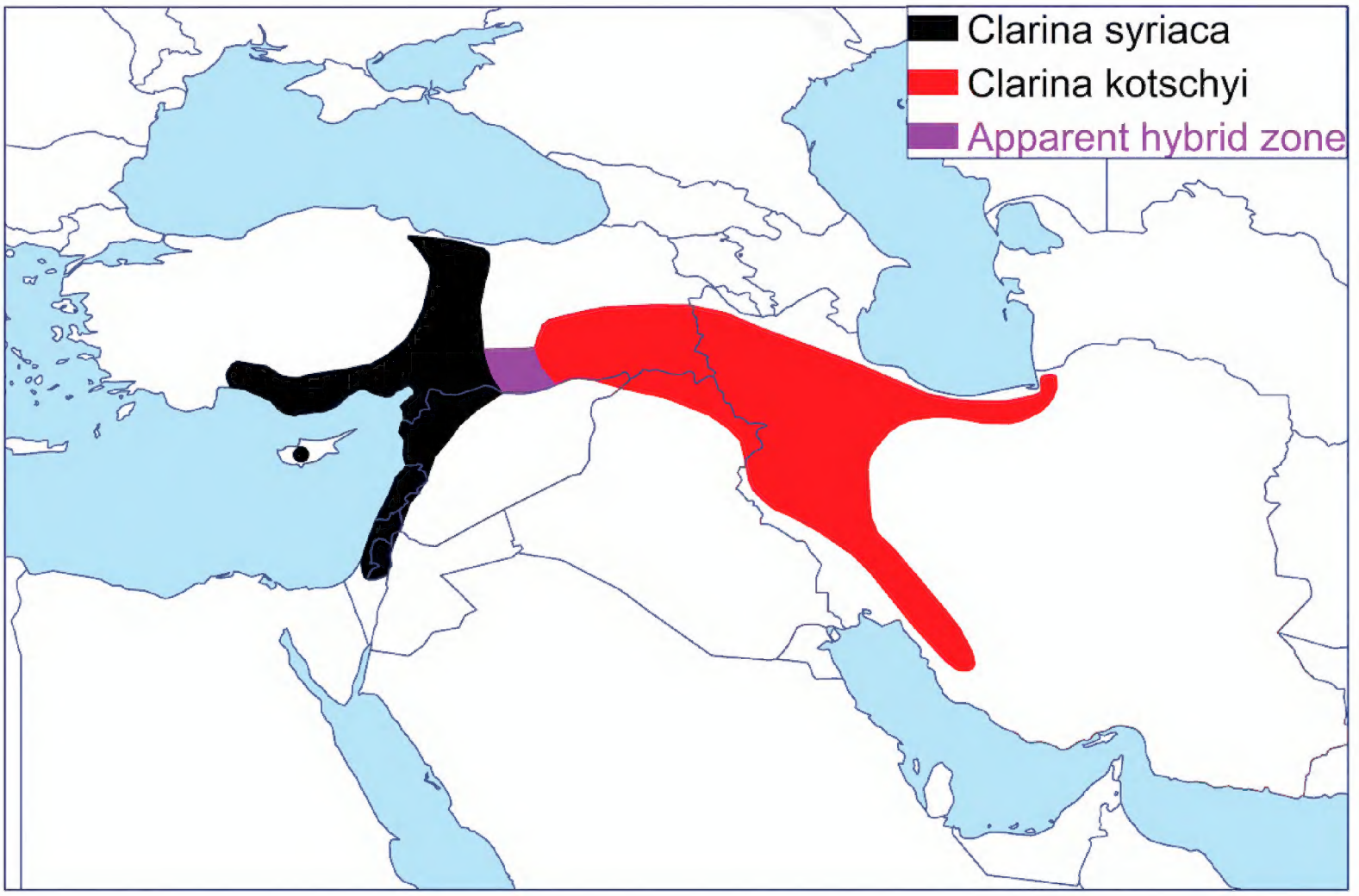

Figure 1. Map showing the estimated distributional range of *Clarina syriaca* (black), *C. kotschyi* (red), and an apparent hybrid zone (purple) between the two species.

The wine-trap was active from 12 August to 17 September 2020, so the exact date of capture is not known. Further searches in the same location on 22 September 2020 with a mercury vapour (MV) light-trap and wine-baits (rope and sponges soaked in red wine) did not yield any further specimens. However, during the following year, on 14 July 2021, a larva (second instar) of what appeared to be *C. syriaca* was found on *V. vinifera* at the same locality. This larva was reared to adulthood (Fig. 2), confirming its identification as *C. syriaca*.

This paper summarises information on the taxonomic status, biology, early life history and ecology of *C. syriaca*, from material and data collected in southern Turkey from around Alanya (during 2004) and from central Cyprus (during 2020 and 2021). The data supports the hypothesis that this species is resident in Cyprus as a relict population living under the same conditions it favours in southern Turkey and the Levant.

Classification and status

Clarina Tutt, 1903 is a western Palaearctic genus containing two closely related species that are very similar to some members of the eastern Palaearctic genus *Ampelophaga* Bremer & Grey, 1853, especially in male genitalia, early stages, and ecology. In fact, a phylogenetic analysis has shown that *Clarina* and *Ampelophaga* are sister genera sharing a common ancestor (Kawahara et al. 2009).

Clarina syriaca appears to have evolved in isolation in the Levant and spread north to Turkey since the last ice age, where it has come into contact and interbred with the closely related *C. kotschyi*, which spread westwards from Iran. It is sometimes difficult to assign individuals from

southeastern Turkey, or even northern Iraq, to either *C. syriaca* or *C. kotschyi*, which suggests a hybrid zone (Fig. 1) (Pittaway 1993). *Clarina syriaca* is often treated as a subspecies of *C. kotschyi* (Pittaway 1982) which, with further study, may turn out to be the case. In other words, they may be two refuge-generated subspecies that have come back into secondary contact since the last ice age and, having had insufficient time apart to fully speciate, are now merging. These contact zones, i.e. post-glacial zones of secondary contact and hybridisation between once-isolated sister species, have been reported for a variety of taxa in many biomes (Remington 1968; Moritz et al. 2009; Hewitt 2011; Portnoy and Gold 2012; Barrowclough et al. 2019; İpekdal et al. 2020).

Nomenclature

Deilephila syriaca Lederer, 1855, Verhandlungen des Zoologisch-Botanischen Vereins in Wien **5**: 195. **TL**: Syria [Lebanon], Beirut.

Accepted name: *Clarina syriaca* (Lederer, 1855).

Figure 2. *Clarina syriaca*, male, reared from a larva collected in Paphos Forest, Cyprus, July 2021. Pupated 4 August 2021 and emerged 18 August 2021. Photo taken by Marios Aristophanous.

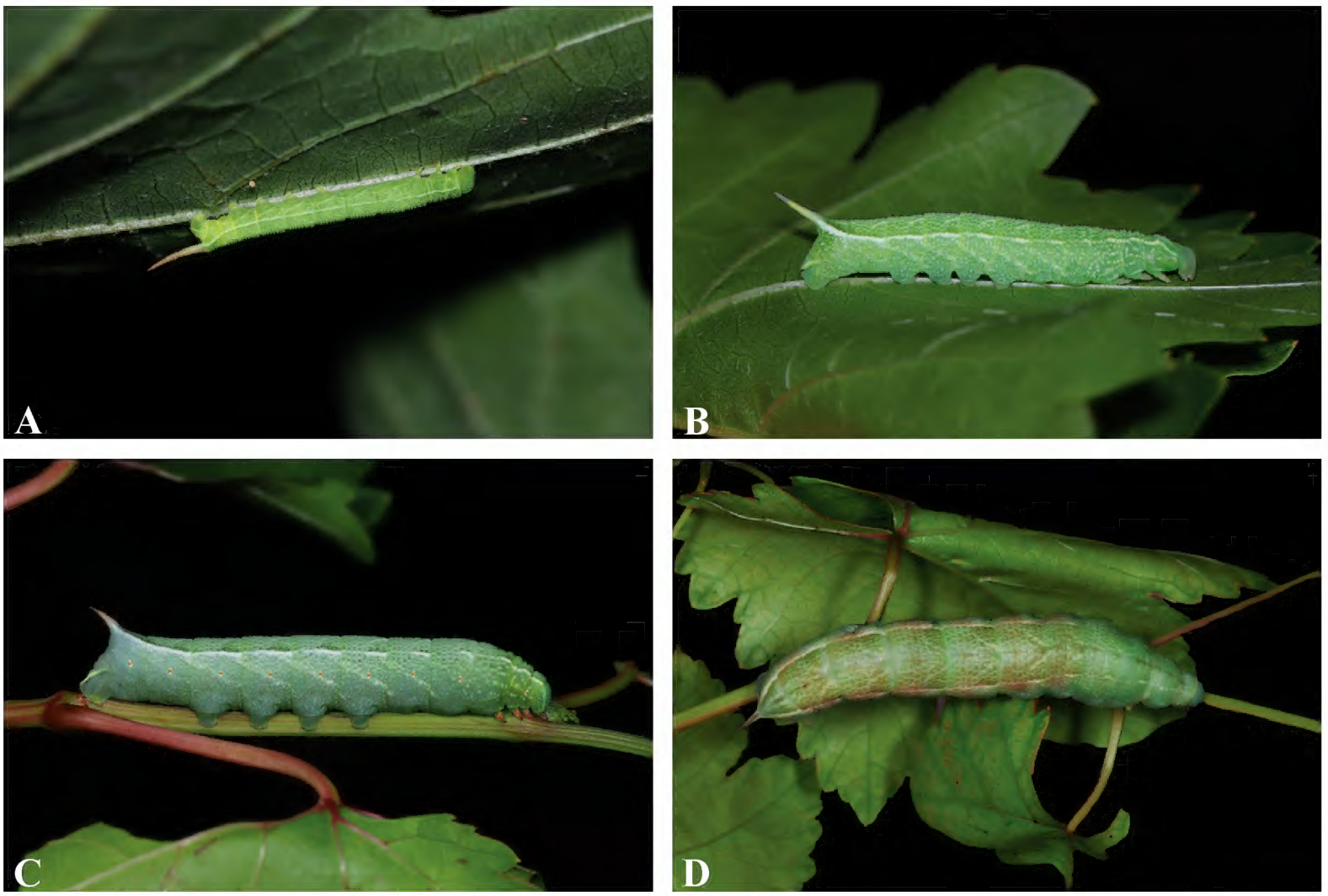

Figure 3. Larva of *Clarina syriaca* in the **A.** Second instar; **B.** Third instar; **C.** Fourth instar; and **D.** Fifth instar (pre-pupal), from Paphos Forest, Cyprus, July 2021. All photos taken by Marios Aristophanous.

Morphology and biology

Adult

(Fig. 2) Wingspan: 50–65 mm. There is considerable variation within the species, especially in ground colour, which ranges from deep reddish-brown to pale grey. The transverse lines on the wings are sometimes very faint; distal margin of the forewing is sometimes without indentations. There is slight sexual dimorphism, with males being lighter in colour and smaller than females (Pittaway 2021).

Ovum

Oval, dorso-ventrally flattened, pale greenish-yellow with a blueish tinge. Laid singly on the upperside of vine leaves (Pittaway 2021). Can sometimes be found intermixed on the same host plant with those of *Theretra alecto* (L., 1758) and *Hippotion celerio* (L., 1758).

Larva

(Fig. 3A–D) Fully-fed 55–65 mm. Typically sphingiform, with the anterior segments retractile into the third thoracic and first abdominal segments. With a series of inverted V-marks down the dorsal surface, one per segment, and a pale, non-ocellate dorso-lateral line. It retains this basic pattern and colouration throughout its development, but thoracic segments 1 and 2 become retractile in the penultimate instar. Develops a brown/purple hue in the fifth (pre-pupal) instar. In the first and

second larval instars, the horn can be either dark grey or pinkish-orange. Found in suitable areas during June and July, and again in September and October (Pittaway 2021).

At all stages of development, the larva rests stretched out along the midrib on the lower surface of a leaf, rarely exposing more than its head and first two segments when feeding. The larva is very secretive and will hide at every opportunity, preferably against a solid surface. When moving, it does so in a slow, measured, jerky fashion. It feeds constantly and consumes large quantities of food by the time it is fully grown (Pittaway 2021). Although larvae can be locally common, they are usually well hidden and difficult to find.

Figure 4. Pupa of *Clarina syriaca* in **A.** Lateral and **B.** Ventral view, reared from a larva collected in Paphos Forest, Cyprus, July 2021. Pupated 4 August 2021 and emerged 18 August 2021. All photos taken by Marios Aristophanous.

Pupa

(Fig. 4A, B) 30–36 mm. The wings are translucent brown, with the veins marked out with lines of dark brown dots, these dots also extending along the legs and antennae. A crescent-shaped mark partly encircles each eye, and the spiracles are set in dark surrounds. Cremaster short and pointed. Proboscis fused to the body.

Host plants

Vitaceae, primarily wild *Vitis vinifera* and feral plants of the domesticated form. However, larvae have also been found on *Parthenocissus quinquefolia* (L.) Planch. in southern Turkey. Under natural conditions, this species generally favours vines of *V. vinifera* hanging down walls and cliffs, growing over piles of rocks, or growing over shrubs as a smothering mass.

Flight period

In southern Turkey and the Levant *C. syriaca* is bivoltine, flying from May to early July (depending on latitude) and again from August to September (Pittaway 1993).

Habitat preferences

In southern Turkey and the Levant, this species favours the rocky raised edges of cultivated valley floors where boulder-strewn streams bordered by vine-covered trees and shrubs occur. A common feature of such locations was found to be water and increased dampness; large numbers of larvae may be present under such conditions. It is also found in gullies on hillsides and in mountain gorges with shrubs and isolated trees, as well as in hillside vineyards where, in Lebanon, it occurs up to 1000 m (Zerny 1933; Ellison and Wiltshire 1939; Pittaway 1993). In southern Turkey, it is common in the small valleys of the foothills of the Toros Mountains where they rise from the coastal plain; however, in both Turkey and Israel (Müller et al. 2005b) it is generally absent from the plain itself. Stone villas and farmhouses with pergolas covered with grapevines are a favoured peri-urban habitat, especially where they are set into the edges of rocky slopes.

Discussion

Clarina syriaca is not a migratory species, as evidenced by no adult having ever been captured away from a breeding population. Thus, the aforementioned specimen is unlikely to have arrived on Cyprus as a migrant from nearby Turkey, Syria, Lebanon, or Israel. Furthermore, if any individuals had migrated to the island then we would have expected them to be first found in coastal areas, rather than the centre of the island in dense forest.

The riparian gallery forest where the second Cypriot adult and the sole larva were found was dark, shady, humid, and bordering (at the time) a dry streambed (Fig. 5). This is a very similar habitat to where *C. syriaca* has been found in Jordan and Israel (Müller et al. 2005a, 2005b). An inspection of the vegetation at the Cypriot locality revealed the presence of *V. vinifera*, which is a known host plant of *C. syriaca* (Pittaway 1993). Many other favourable localities (i.e. streambeds with grapevines) were searched for the presence of larvae but none were found. This could be due to the elusiveness of the larvae and/or possibly low or very localised populations of *C. syriaca* in Cyprus.

The host plant is very abundant in Cyprus due to its extensive cultivation for the production of wine. Moreover, the wild ancestral grape, *V. vinifera* subsp. *sylvestris* (Gmel.) (as opposed to the cultivated *V. vinifera* subsp. *vinifera*) has been noted as being indigenous to Cyprus, as well as

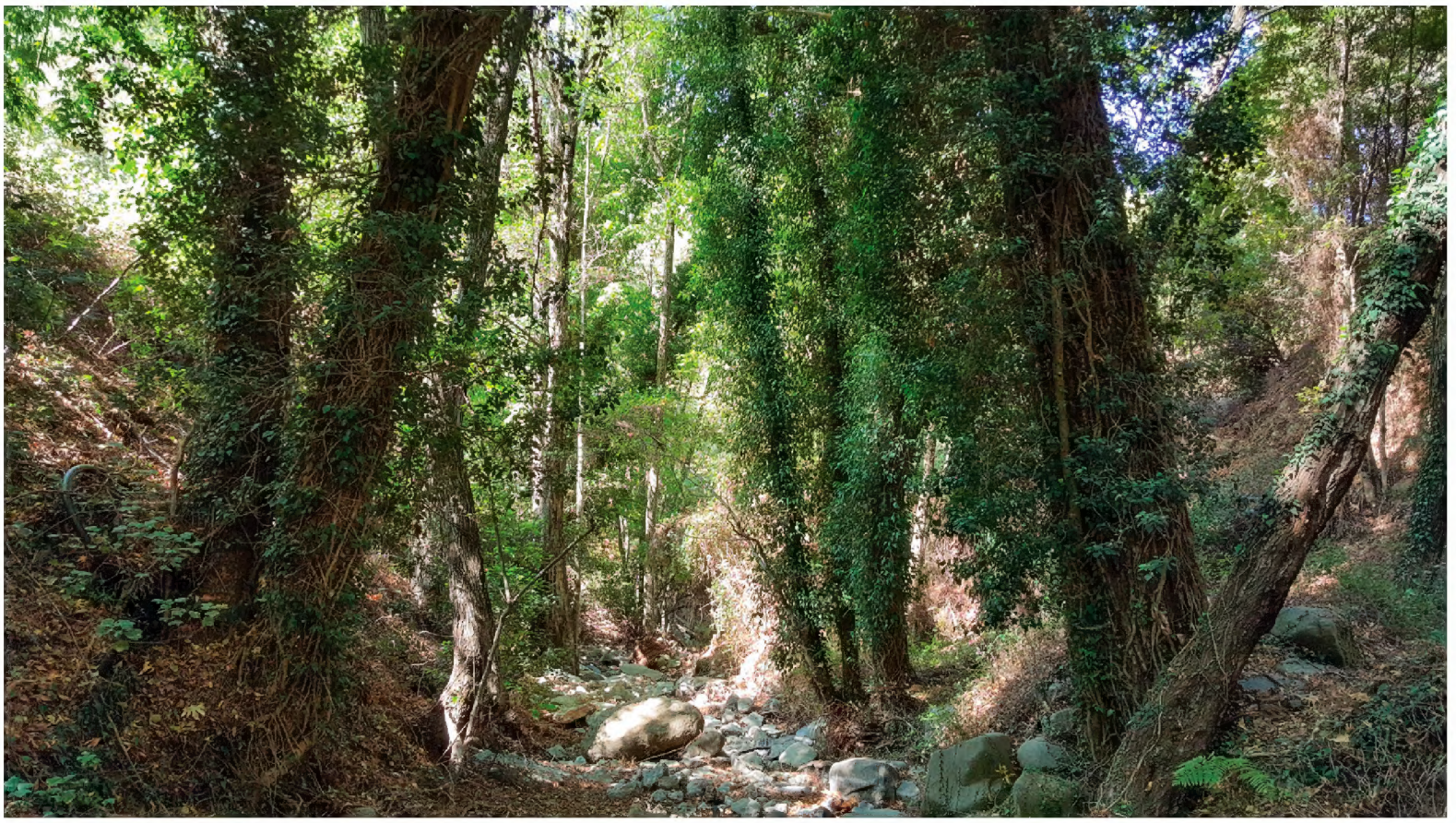

Figure 5. The streambed and riparian habitat where the second adult specimen and sole larva of *Clarina syriaca* were found in Cyprus. Paphos Forest, 550 m. Photo taken by Marios Aristophanous.

central and south-eastern Europe, the Caucasus, Turkey, and eastwards to Turkestan and Kashmir (Meikle 1977). The preferred habitat of *V. vinifera* subsp. *sylvestris* is thickets and wooded ravines in forests with abundant water (Meikle 1977; Zdunic 2017). Thus, unsurprisingly, the habitat of *C. syriaca* matches that of *V. vinifera* subsp. *sylvestris* and not *V. vinifera* subsp. *vinifera*. That is, *C. syriaca* seems to avoid open, exposed and sunny locations (i.e. hot and dry conditions), such as those represented by most agricultural vineyards (Pittaway 1993). This was also found to be the case in southern Turkey. Furthermore, the use of pesticides on commercial grapevines would surely eradicate any larvae that attempted to feed there. Thus, as commercial vineyards are not preferred/utilised by *C. syriaca*, this only leaves the wild or escaped grapevines that are found along small valleys with streams, and watered ornamental grapevines grown around houses. These provide the necessary microclimate (i.e. lower temperatures and higher humidity) for the survival of *C. syriaca*.

This microclimatic preference suggests that *C. syriaca* is a monocentric Pleistocene relict species from the Syrian refuge (Pittaway 2021) that has managed to survive in the western Palaearctic in isolated ravines, together with its host-plant *V. vinifera* subsp. s*ylvestris*. Thus, small stands of riparian gallery forest in deep valleys with streams act as present-day refugia for this species. These "islands" have tended to become surrounded by a "sea" of unsuitable hotter and drier environments, like pine woodlands and cultivated land.

The flight periods and number of generations of *C. syriaca* in Cyprus were until recently unknown, as only a single adult specimen was known. However, based on the additional records mentioned in this paper, we can deduce that *C. syriaca* is also bivoltine in Cyprus. That is, the first (1950) adult was found on 19 June, corresponding to the emergence of a first generation from an overwintering pupa. The second adult was found sometime between mid-August and mid-September 2020, indicating a second-generation. The 2021 larva was found on 15 July, which corresponds with it being part of a first-generation. This larva was reared, with the adult moth emerging on 18 August.

The timing of this emergence corresponds with the 2020 second-generation moth mentioned above. The second-generation larvae pupate and overwinter until the following year, as there is insufficient time to produce another generation before autumn and winter set in. The above is indicative of there being two generations in Cyprus and is thus similar to the known life cycle in Turkey and the Levant.

Despite the abundance of host plants, it remained unclear for many years as to why no other specimens of *C. syriaca* had been found in Cyprus since 1950, and why it was considered a rare species throughout its range. However, biological and ecological observations by one of the authors (ARP) in southern Turkey have shown that this species is not rare at all, and that it is quite common in favourable locations.

How did this misconception arise?

First, *C. syriaca* may have avoided detection because adults are rarely, if ever, attracted to light, which is a common method used by entomologists to sample and study insects, especially moths. In June 2004, an MV light-trap was used at and near a villa at Yeşilöz, near Alanya, in southern Turkey, around which *C. syriaca*, *T. alecto* and *H. celerio* were actively laying eggs. Whereas adults of the latter two species were attracted to the light, no adults of *C. syriaca* were seen. Each day, newly laid eggs of *C. syriaca* were found on grapevines overhanging a pergola, but no ovipositing adults were ever seen during the night. Second, the larvae are very secretive and difficult to find. Eggs, however, are much easier to spot.

Conclusion

Here, we report the discovery of a second adult specimen, as well as the first record of a larva of *C. syriaca*, from Cyprus, indicating that this species breeds and has a resident population in Cyprus.

The preferred habitat of *C. syriaca* in Cyprus matches that given for southern Turkey, Israel and Jordan. As both a larva and an adult were found at the same site, one year apart, it is presumed that this species is resident in the mountain river gorges of central Cyprus as a relict population. That only three specimens have been found is attributable to the adult moths not being attracted to light, the local nature of populations, and the secretive nature of the larvae. Until further investigations elucidate the distribution of *C. syriaca* in Cyprus, we cannot rule out the possibility of this species having sparse and very localised populations.

More studies are also warranted to identify the refugial role of riparian gallery forests in Cyprus and their influence on local and regional patterns of species diversity. Additional studies are also needed to determine whether *C. syriaca* and *C. kotschyi* are indeed separate species and not refuge-generated subspecies. It should be noted that previous attempts by ARP to rear *C. syriaca* and *C. kotschyi* in captivity with the aim of hybridising them have failed in that siblings refused to mate with each other.

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